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(Problem 1)

FINAL REPORT

TEST OF A TECHNIQUE FOR REARING MITE-FREE SOUTHERN PINE BEETLE ADULTS

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TEST OF A TECHNIQUE FOR REARING MITE-FREE SOUTHERN PINE BEETLE ADULTS

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John C. Moser

The attached manuscript, "A technique for rearing mite-free southern pine beetle adults," serves as the final report for this study. The manuscript has been submitted for publication to the Annals of the Entomological Society of America. A paper under the same title was presented at the Annual Meeting, Entomological Society of America, Toronto, Canada, November 30, 1982.

This study is closed.

INTRODUCTION

About 15 species of mites are commonly transported by the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann 1868 (Moser and Roton 1971, Kinn 1976), with the proportion of phoresitized flying adults conservatively estimated at about 40% (Moser 1976).

The trophic habits of these phoretic mites vary widely, ranging from predaceous, mycophagous, nematophagous, or saprophagous to various combinations of feeding preferences. Some are detrimental to the SPB, others are neutral or beneficial (Kinn 1967, 1980; Moser 1975; Wilson 1980). Many numerous and complex relationships exist among these mites and the SPB; hence mites must be excluded from future laboratory and field studies to determine the capacity of SPB to attack trees and produce broods in the absence of selected associates.

At present there are no efficient methods for obtaining large numbers of SPB free of phoretic mites. Mechanically removing mites invariably injures the beetles because the elytra has to be lifted. Rearing beetle adults from eggs on artificial media is tedious and time consuming, and very few adults are produced (Bridges 1979).

Kinn (1979) first documented that desiccation of the phloem killed some mite species. Subsequent studies by the authors showed that desiccation might severely reduce or eliminate all mite populations, resulting in virtually no phoretic mites on emerging beetles. In this study we decided to see whether mite-free populations of SPB could be reared from desiccated host material.

METHODS AND MATERIALS

Four loblolly pines (*Pinus taeda* L.) infested with SPB were cut during February, May, August, and December 1980. The trees were from a natural stand about 35 years old in the Catahoula Ranger District of the Kisatchie National Forest. Trees were felled when the SPB broods were pupae in the outer bark. Pupae do not carry phoretic mites (Roton 1978).

Samples were taken from the bole area where the pupal stage was most concentrated and where competition from other bark beetle species was least. Typically, the sample area extended from 5 m through 11 m from ground level. No attempt was made to normalize infested bole heights within trees (McClelland et al. 1979), because our objective was not to sample tree populations systematically.

The infested bole area of each tree was divided into 5 sections. Each section was subdivided into 3 sample bolts which were trimmed so that each contained 2,880 cm^2 of bark area. The uppermost bolt of each section was a survey bolt. A sixth survey bolt was taken from just below the first section. The other two bolts of each section were randomly assigned to one of two treatments. For one treatment the bark was removed and exposed to the air inside the laboratory for 36 hours. For the other treatment (control) the bark was not removed. Material from both treatments was placed in individual rearing cans inside the laboratory and kept at about 20^{o}C and 50% RH. The can interiors were dark with little or no air movement.

The survey bolt of the middle section was used to determine how long mites survived on the inner surface of drying bark. The mite surveys were made within 30 minutes after the bolts were cut, and then hourly for six hours. Subsequent observations were made at 12 and 24 hours, then daily until mites were no longer observed.

In a preliminary survey at the start of the experiment, all the bark of the other 5 survey bolts was examined to establish which species of mites were present and to estimate their relative abundance.

Inner bark moisture readings were measured with a model RC-1 Delmhorst[2/] moisture detector. Readings were taken from the mid-section of all 10 bolts within 30 minutes after they arrived from the field. Moisture readings were also recorded from the inner bark of the five stripped bolts. Thereafter inner bark moisture readings were made daily from one pair only.

To determine whether brood adults preferred to emerge through the inner bark or outer bark, three 875-cm^2 bark samples were placed in darkened rearing cans, held until emergence was complete, and the subsequent emergence holes counted.

Data were analyzed using the Statistical Analysis System[3/]. To determine the effect of bark removal on beetle emergence an analysis of variance was run using a split plot design. The whole units were locations along the infested bole, and the subunits were treatments. The response variable was total number of beetles that emerged. To determine which species of mites the beetles carried most often, a split-plot design was used with locations on the infested bolt as the whole units and mite species as the subunits. Duncan's multiple range test was used to compare means.

RESULTS

The 7,826 brood adults emerging from the bark that had been removed were essentially mite free; a little over 1% carried mites. Of the 107 beetles with mites, all but one emerged within 3 days but none after the 4th day (fig. 1). Of the 8,065 brood adults emerging from the control, 85% carried at least one mite (fig. 2).

Bark removal did not affect the number of beetles that emerged; there were no statistically significant differences in the mean number of beetles that emerged due to location along the infested bole (Table 1). Beetles emerged through both sides of the removed bark but twice as many emerged through the inner bark (fig. 3) as through the outer bark.

In the preliminary survey of the inner bark, we located all of the mite species that were later found phoretic on emerging SPB (Table 2); all were common or infrequent. In addition to these, the preliminary survey also revealed *Macrocheles boudreauxi* Krantz 1965, *Eugamasus lyriformis* McGraw and Farrier 1969, and *Proctolaelaps hystricoides* Lindquist and Hunter 1965, which were not found on the emerging SPB; these mites were also infrequent. *Macrocheles boudreauxi* and *E. lyriformis* are phoretic on SPB (Moser and Roton 1971). *Proctolaelaps hystricoides* commonly occurs in SPB galleries, but never has been observed to ride SPB. But it is phoretic on two beetle associates of SPB.

Mites could be found at any time on the inner bark of control bolts, but they disappeared within 24 hours after bark removal. This coincided with a drop in moisture. The initial moisture content of inner bark in intact bolts was 35 to 50% dry weight and gradually dropped to 25 to 35% during the 20 to 30 day emergence period. Inner bark moisture content of removed bark dropped from 50% to about 7% within 24 hours and remained at that level throughout the emergence period.

In the control treatment, beetles most often carried *Tarsonemus ips*. Beetles with *Dendrolaelaps neodisetus* and *T. krantzi* were the next most numerous (Table 2). Mites carried by beetles from the removed bark reflect those found in the control treatment.

DISCUSSION

The procedure of bark removal provides an easy and efficient way of providing large numbers of mite-free beetles. To be reasonably sure of obtaining mite-free beetles from removed bark, one should keep only those beetles emerging after the fourth day.

A previous report (Moser 1976) reported that 39.6% of flying adult SPB were found to carry mites. The figure we obtained in the present study (85%) was much larger, but the previous study was based on SPB taken from sticky traps and probably reflected losses of loosely attached mites trapped by the stickum.

To our knowledge this is the first record of southern pine beetles emerging "in reverse" through the inner bark. Miller and Keen (1960) state that *Dendroctonus brevicomis* LeCompte 1876 emerge through the bark surface facing the light; or if light is absent, they apparently take the shortest way out.

Mite-free beetles may occur in nature when woodpeckers flake off bark containing SPB brood. If these flakes dry out, they may create local sources of mite-free beetles. Although we have neither reared nor examined any beetles from bark flakes, we have seen flakes in the field with SPB emergence holes in the inner bark when the inner bark lies face-up on the ground.

Because brood adults emerging from bark flakes may not carry mites, their ability to perpetuate the population in forest stands may be reduced. The absence of *Tarsonemus* mites would lessen the number of *Ceratocystis minor* (Hedgcock 1906) Hunt 1956 (bluestain fungus) ascospores transported to attacked trees (Bridges and Moser 1982); the absence of *Dendrolaelaps neodisetus* Hurlbutt 1967 and other nematode feeders could raise the incidence of nematode parasitism in the bark beetles (Kinn 1980).

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FOOTNOTES

1/ *Dendroctonus frontalis* Zimmermann 1868.

2/ Trade names and company names are included to identify equipment used, and do not constitute endorsement by the USDA.

3/ SAS Institute, Inc., SAS Circle, Box 8000, Cary, NC 27511.

Table 1.--Number of beetles emerging from bolts with bark intact (control) or bark removed.

Bole Section[1]	--Mean no. of emergent beetles[2]--- Bark intact	Bark removed
1	405	380
2	444	539
3	354	332
4	437	355
5	375	350

[1] Bole sections were numbered starting with the lower section.

[2] Mean of four trees.

Table 2.--Mite species and number of southern pine beetles that carried them.

Mite species	-----Beetles per bolt*------	
	Bark intact	Bark removed
Tarsonemus ips	277 a	4.35 a
Dendrolaelaps neodisetus	107 b	1.30 b
Tarsonemus krantzi	102 b	1.00 b
Trichouropoda australis	54 bc	0.40 b
Histiogaster arborsignis	14 bc	0.30 b
Ereynetoides scutulis	1 c	0 b
Proctolaelaps dendroctoni	< 1 c	0 b

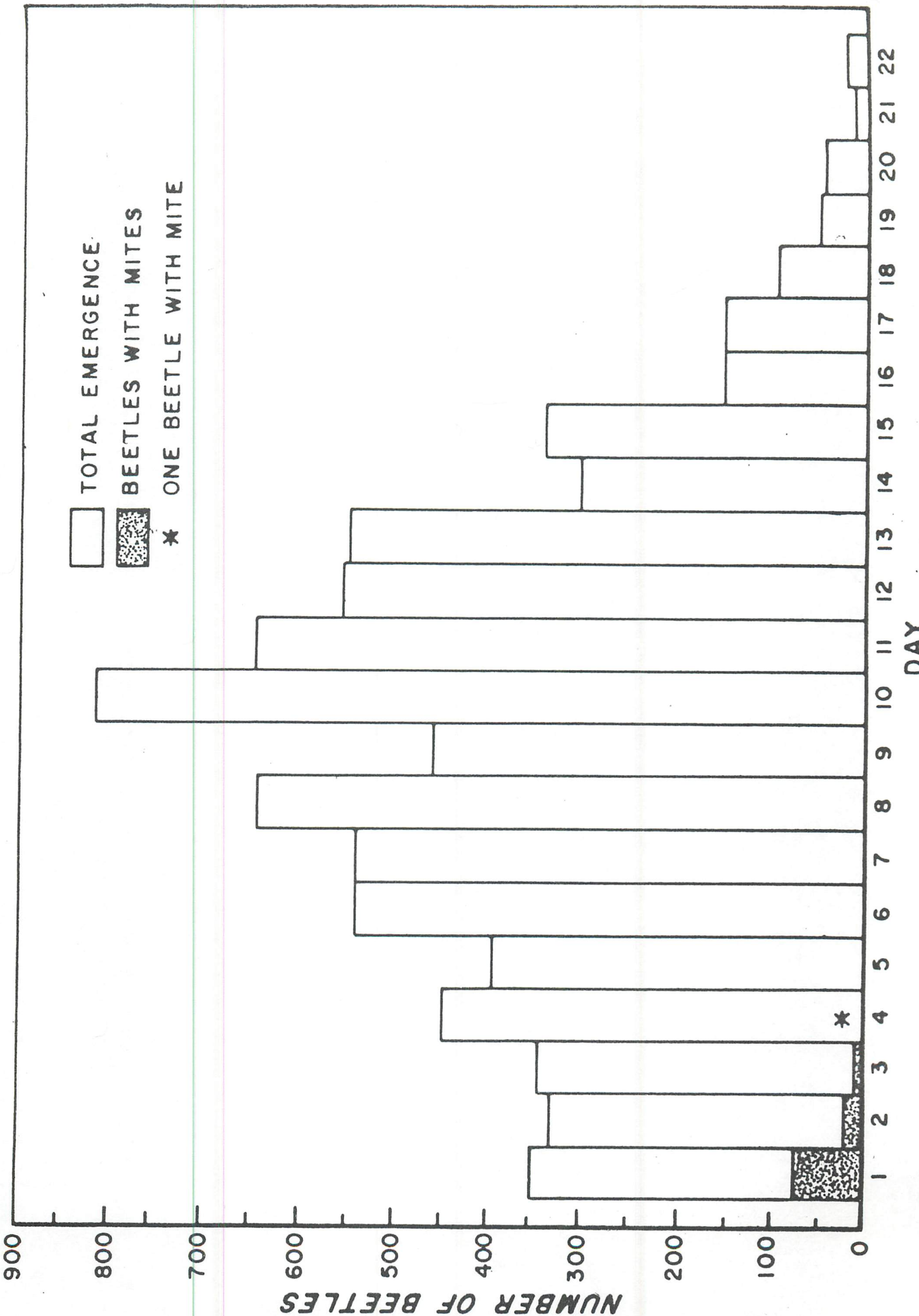
*Mean of 20 bolts. Column means followed by the same letter are not significantly different at the 0.05 level.

FIGURE CAPTIONS

Fig. 1.--Beetle emergence from removed bark.

Fig. 2.--Beetle emergence from intact bark.

Fig. 3.--Inner surface (inner bark) of removed bark showing beetle emergence holes (arrows).


TOTAL EMERGENCE
BEETLES WITH MITES
ONE BEETLE WITH MITE
NUMBER OF BEETLES
0
100
200
300
400
500
600
700
800
900
DAY
1
2
3
4
5
6
7
8
9
10
11
12
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19
20
21
22

Figure 1.

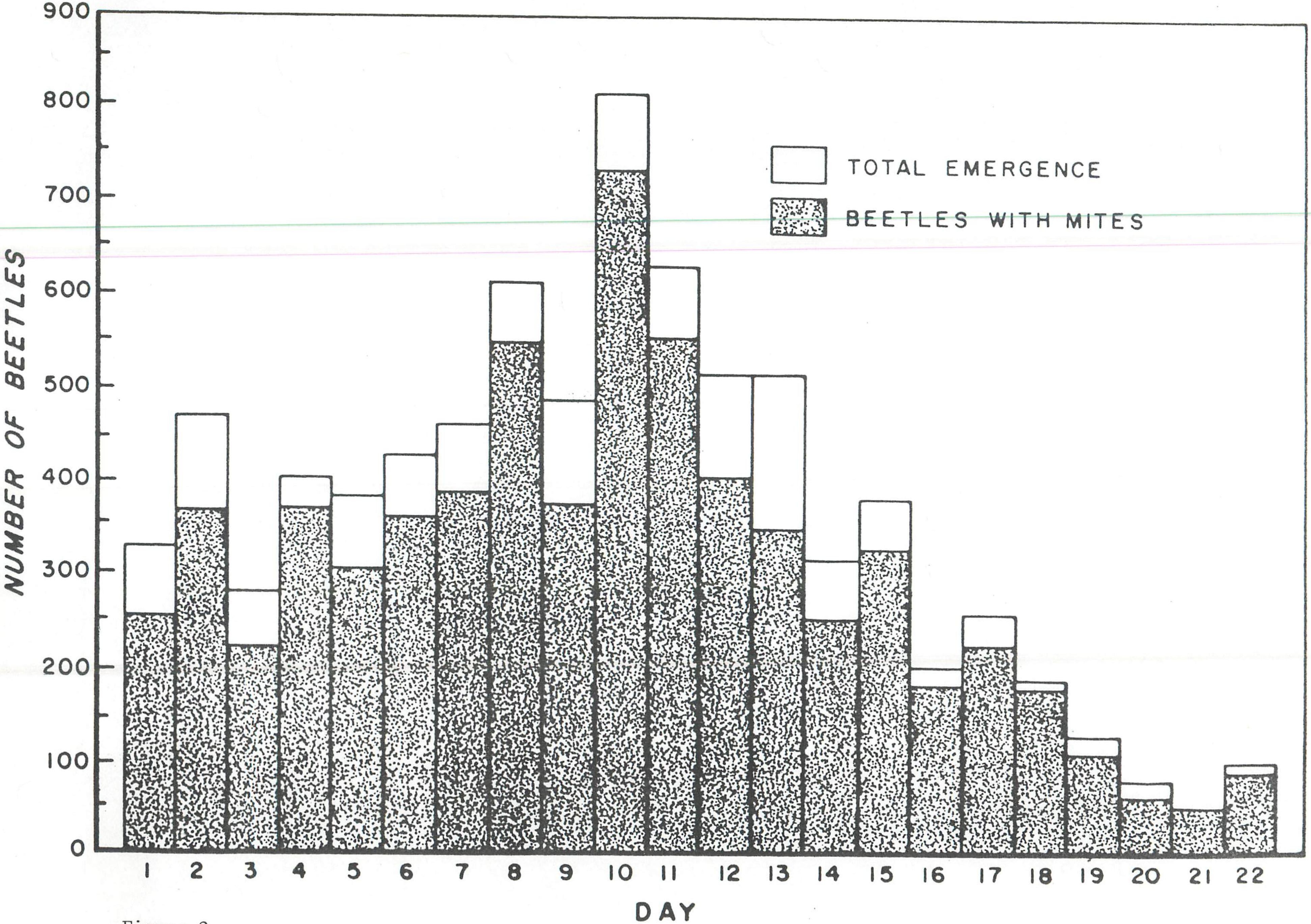
900
800
700
600
500
400
300
200
100
0
NUMBER OF BEETLES
TOTAL EMERGENCE
BEETLES WITH MITES
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
DAY

Figure 2.

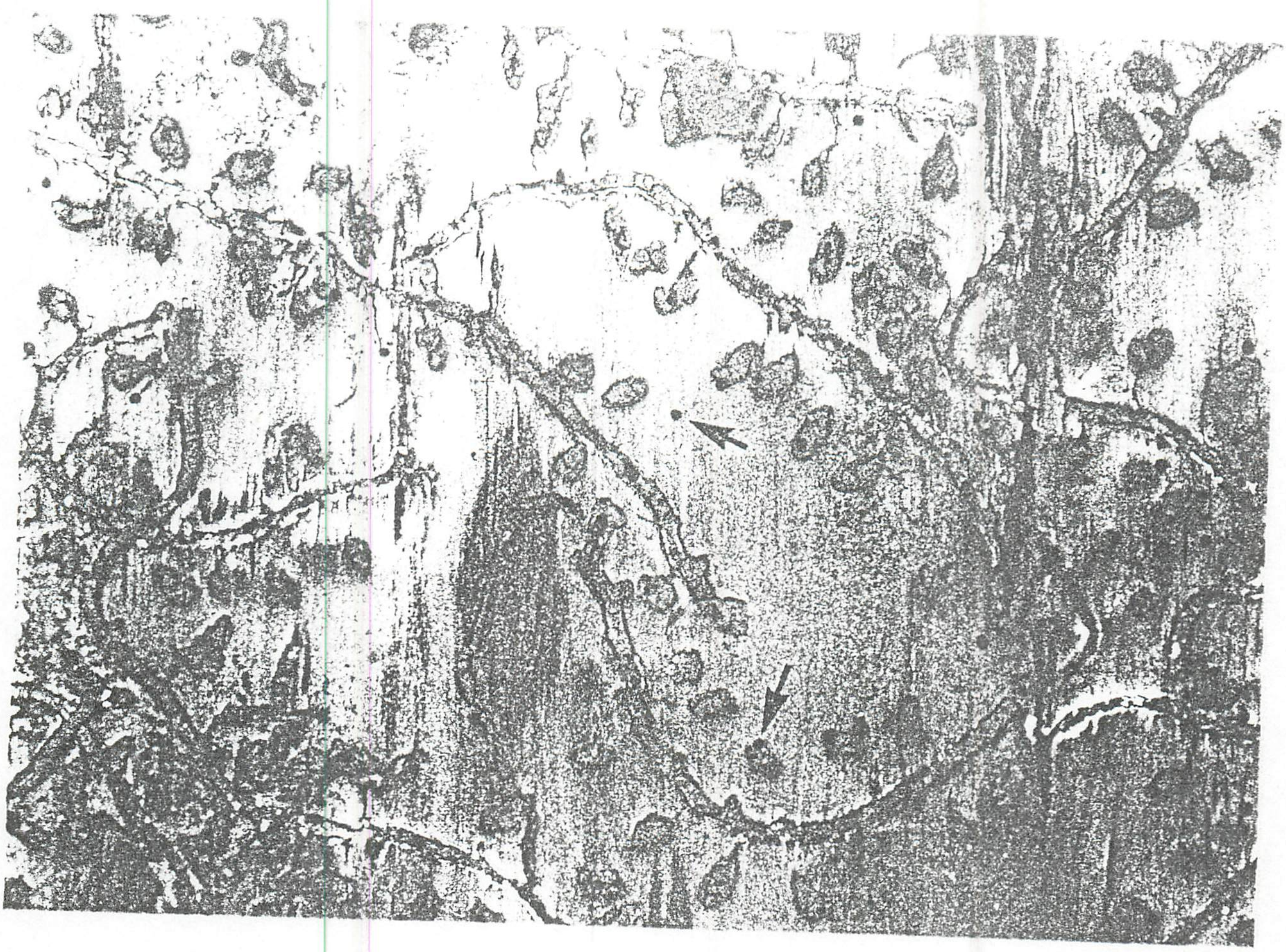

Fig. 2.